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# NATIONAL BUREAU OF STANDARDS REPORT

10 327

SPREAD OF FLAME TESTS ON FIVE MATERIALS  
ISO/TC 92 WG4



U.S. DEPARTMENT OF COMMERCE  
NATIONAL BUREAU OF STANDARDS

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<sup>1</sup> Headquarters and Laboratories at Gaithersburg, Maryland, unless otherwise noted; mailing address Washington, D.C. 20234.

<sup>2</sup> Located at Boulder, Colorado 80302.

<sup>3</sup> Located at 5285 Port Royal Road, Springfield, Virginia 22151.

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## SPREAD OF FLAME TESTS ON FIVE MATERIALS ISO/TC 92 WG4

by

D. Gross

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## 1.0 TEST PROCEDURE

The same test procedure was used for these tests as previously described in test report "Preliminary Spread of Flame Tests - ISO/TC 92 WG4."

The panel was operated at a blackbody temperature of 750 °C, corresponding to a radiation intensity of 6.3 w/cm<sup>2</sup>. No canopies or skirts were used. The edges of all specimens were coated with sodium silicate, and all specimens were conditioned to constant weight at 23 °C and 50% relative humidity.

## 2.0 TEST MATERIALS

The test materials comprised the five materials supplied by ISO member countries, as listed below, plus two carpeting materials for test in the "floor" orientation only.

Material No.	Designation	Supplied By	Thickness		Density	
			(nominal) in	mm	pcf	kg/m <sup>3</sup>
1	Panel Board (Hardboard)	Denmark	1/2	12	41	660
2	Melamine-faced Chipboard	U. K.	11/16	18	50	800
3	Red Oak	U. S. A.	3/4	20	42	680
4	Rigid Polystyrene (FR)	Germany	3/4	20	1.0	16
5	Rigid Polyurethane	Belgium	7/8	26	2.4	38
6	Acrylic Shag Carpet	-----	79.5 oz/yd <sup>2</sup> (2.70 kg/m <sup>2</sup> )			
7	Nylon Twist Carpet/Hair Pad	-----	63.8 oz/yd <sup>2</sup> (2.16 kg/m <sup>2</sup> )			



### 3.0 RESULTS

Typical results are shown graphically for the four orientations in Figures 1, 2, 3 and 4. The distance-time plots are on semilogarithmic coordinates which had previously resulted in generally straight lines, except for the "wall" position.

The floor position gave the greatest discrimination (or difference) between polyurethane foam and the other materials. The polystyrene foam sustained flame near the pilot flame, and burned to 85 mm on the molten portions, but otherwise only melted out to a distance of 675 mm. On acrylic shag carpet, the flames traveled to the limit of the specimen in less than 6 minutes. Typical results are listed in Table 1.

The ceiling position was the only position to give measurable flame spread for all five materials. Due to the increased contribution from flaming combustion in this position, flaming generally extended furthest. This position gave the greatest discrimination between hardboard and red oak. The plots were linear or very nearly so.

The wall position test reversed the ranking of the melamine-faced chipboard compared to the floor and ceiling positions. The polystyrene foam melted but did not burn. The flame advance was greater at the top of the specimen, and the distance-time plots were generally non-linear.

In the incline position, the differences between materials was not as great as in the other positions.

The ranking order of the materials was consistent (polyurethane most rapid spread; melamine-faced chipboard least rapid spread) for four materials (polystyrene excluded) in all positions except the wall position.

### 4.0 DISCUSSION

In the absence of any discrete suggestions as to how to express the performance of materials by this test, the following may be considered:

- (A) (1) Plot distance (mm) versus time (min) on semilogarithmic coordinates.
- (2) Draw a straight line through the data points if possible; a curve where appropriate.
- (3) Read the value of distance at a time of 1 minute (extrapolate the straight line or curve, if necessary).

(B) Calculate a flame spread index based on the following:

$$FSI = 1 + \frac{1}{t_{75}} + \frac{1}{t_{150} - t_{75}} + \frac{1}{t_{225} - t_{150}} + \dots$$

where  $t_{75}$ ,  $t_{150}$ ,  $t_{225}$ , ..... represent time in minutes for flames to reach the 75, 150, 225, ..... mm mark. This represents a sum of progressive flame spread rates, in which the contributions are added from all segments which propagate flames.

Using the "1 minute distance" as a test criterion, the distances ranged from 60 mm for the melamine chipboard to 350 mm for the polyurethane foam and acrylic carpet in the floor position. Similar measurements can readily be made for the ceiling, wall and incline positions.

Using the "flame spread index" as a test criterion, the floor position values ranged from 1.0 for the fire-retardant polystyrene foam which did not yield a flame front, to 2.0 for the melamine chipboard to 51.4 for the polyurethane foam. The acrylic carpet, on which the flame front traveled the full length, received an index of 43.1. It did not spread flames initially as rapidly as the polyurethane foam.

Flame spread index values for the five round-robin materials in all four positions are listed in Table 2. The index is, with few exceptions, highest in the ceiling position, next highest in the incline position, and lowest in the floor position.





Table 1. Flame Spread Data

## FLOOR POSITION

Distance mm	TIME, min						
	Panel Board MFT*=525	Melamine Chipboard MFT=135	Red Oak MFT=360	Polystyrene Foam (FR)	Polyurethane Foam MFT=430	Acrylic Carpet MFT=1000	Nylon Carpet MFT=760
Sustained Flame	.16	.24	.20	.02	.02	0	.02
75	.72	1.46	.85		.05	.09	.47
150	1.63	4.36**	2.30		.10	.32	1.39
225	3.29		4.52		.27	.50	2.88
300	5.73		8.65		.62	.77	5.54
375	9.08		15.00**		1.23	1.09	9.43
450	13.56					1.50	14.35
525	19.56					2.07	23.00
600						2.74	32.88
675						3.46	44.76
750						3.92	58.93
825						4.65	
900						5.39	
975						5.83	

\* MFT = maximum flame travel

\*\* Time to MFT

Flame Spread Index	5.14	2.02	3.71	1.0	51.38.	43.13	6.1
1-min distance, mm	105	60	85	---	350	350	120

Table 2. Flame Spread Index Values

$$\text{Index} = 1 + \Sigma \frac{1}{\Delta t}$$

	Position			
	Floor	Ceiling	Wall	Incline
Panel Board	5.1	25.3	7.4	12.2
Melamine Chipboard	2.0	8.2	6.1	8.3
Red Oak	3.7	10.5	5.2	8.8
Polystyrene Foam (FR)	1.0	58.6	1.0	1.0
Polyurethane Foam	51.4	130.2	33.7	27.5

Figure 1

# FLOOR

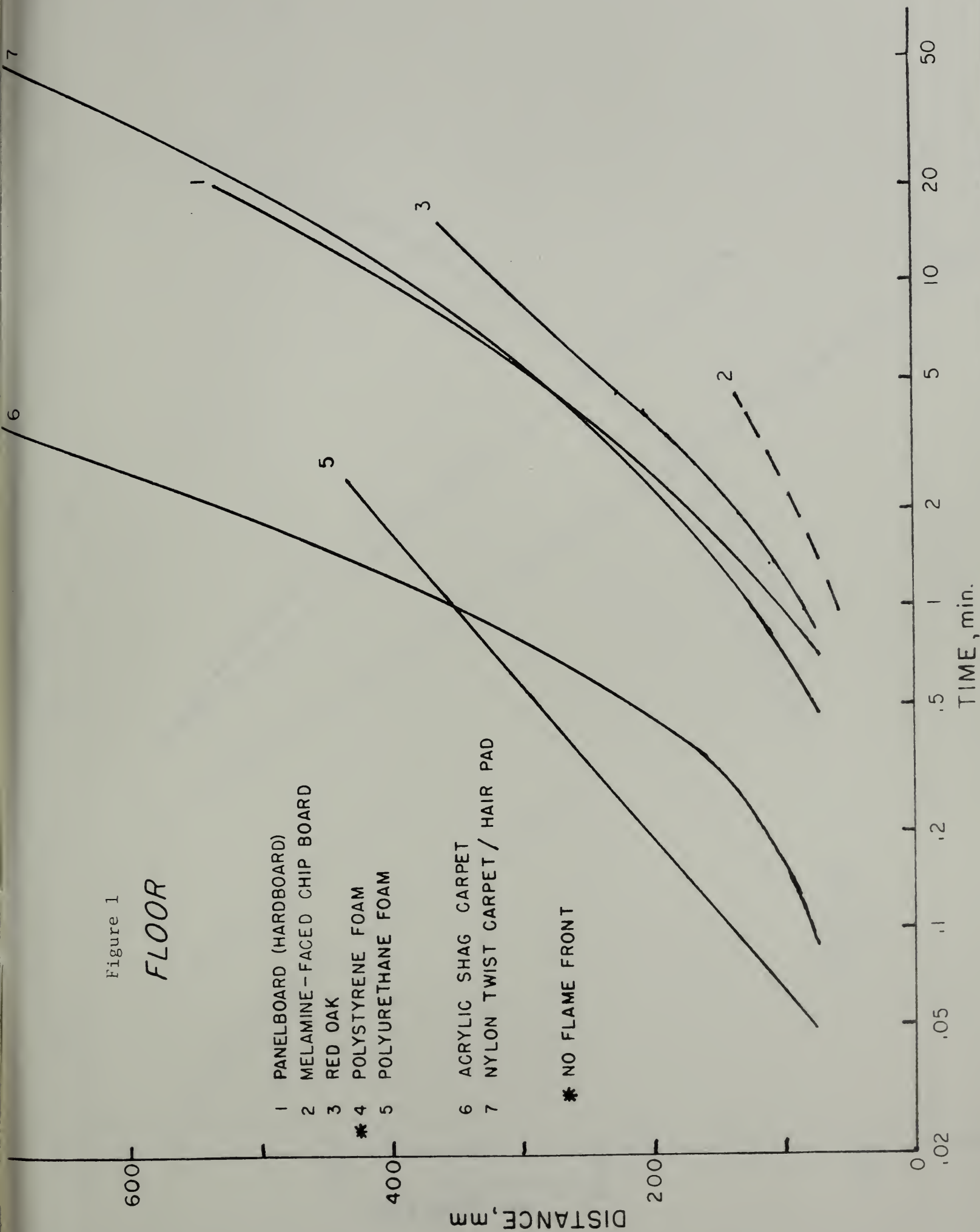


Figure 2

CEILING

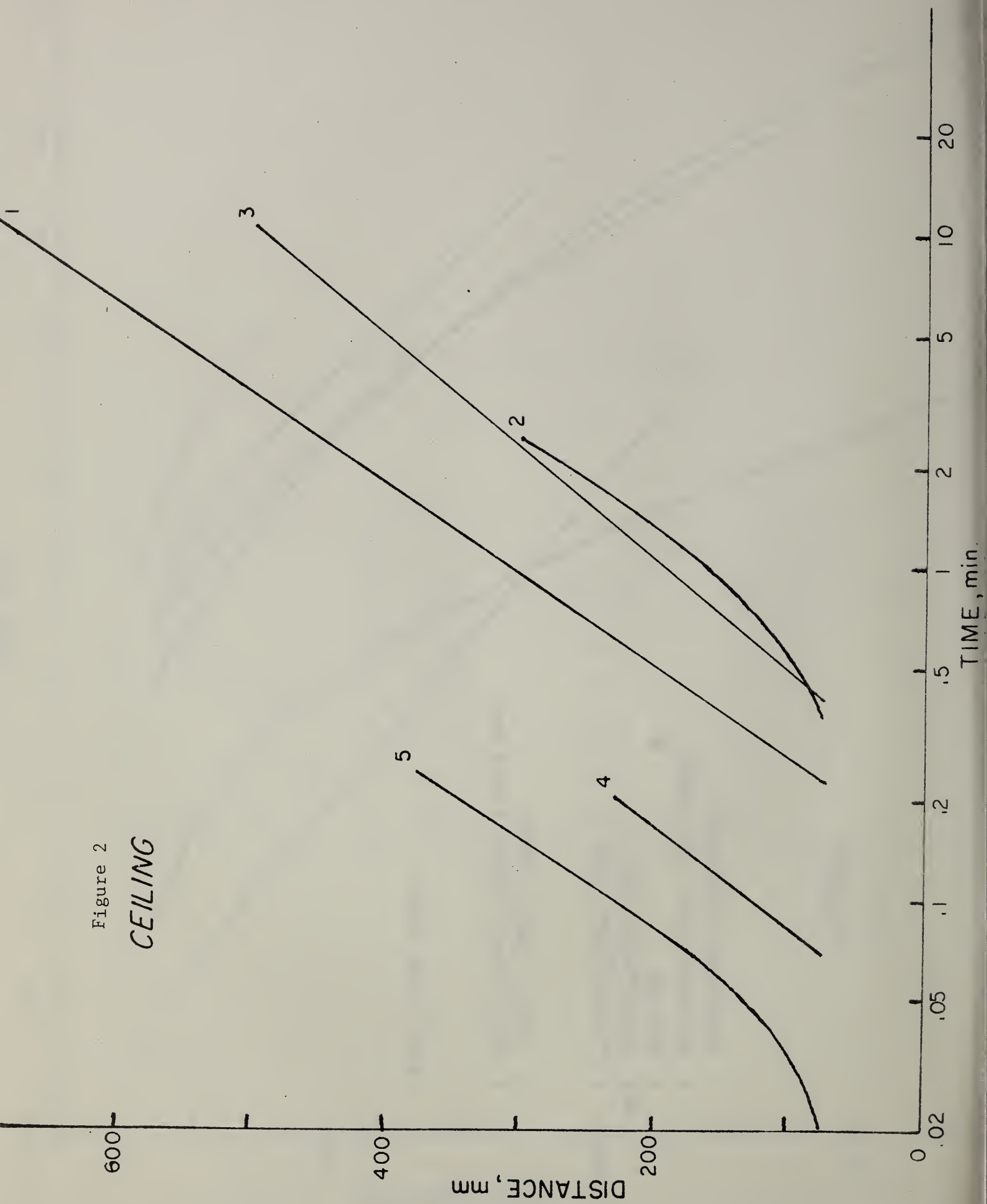


Figure 3

WALL

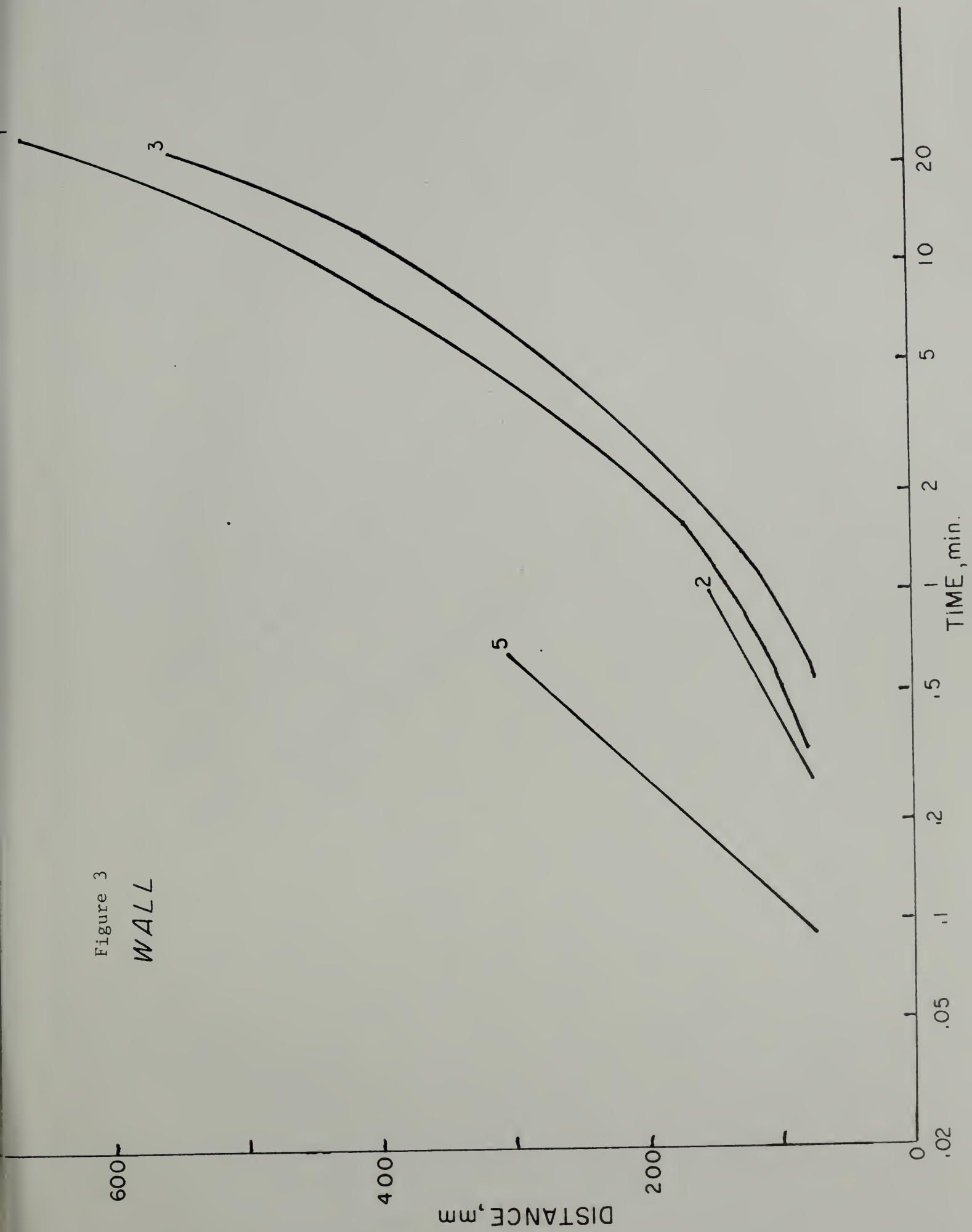




Figure 4

*INCLINE*

